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ANALYSIS OF PROTECTION OF ELECTRONIC INFORMATION IN THE GULF WAR

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Abstract: In the Gulf War in early 1991, the most lethal and most expensive weapons were not the guided missiles, fighter craft, tanks, or warships, but the electronic information system deployed by the multinational troops in the Gulf area led by the United States. This information system was large-scale, advanced in technology, strict in organization, and high in operational efficiency, providing the overall, precise, timely, and continuous information about Iraqi troops to the multinational troops in its various command structure levels. Thus, the demand for prescribing combat plans and command execution was ensured, to have key functions in winning the war. The Gulf War was a concentrated manifestation of the modern informationized battleground. In the view of the U.S. forces, the Gulf War signaled the conclusion of a combat era and marked the coming of the C3I era. Therefore, analysis on the electronic information

protection system in this war is very important and significant to cope with combat in the future high-tech conditions.

Key Words: electronic information, electronic services, information analysis.

In the Gulf War, air raids, electronic countermeasures, precision guided weapons, and other advanced weapons were extensively applied to increase the demands of information protection to the greatest extent. Led by the United States, the multinational troops utilized the electronic reconnaissance systems in space, air, at sea, and on land, to form a vast electronic information protection system. This electronic information protection system was large in scale, advanced in technology, strict in organization, and high in operational efficiency, thus having great functions in ensuring combat victories of the multinational troops.

I. Missions and Requirements of Electronic Information Protection

Information is the basis of prescribing a combat execution plan; this is an indispensable element for combat protection.

1.1. Missions of electronic information protection

Mainly, there are five aspects of these missions of electronic information protection in the Gulf War.

(1) Selection of targets to be bombed: Since the multinational troops regard air raids as the main combat pattern

in destroying the Iraqi forces, selection of bombing targets was vital in electronic information protection. The multinational forces included the following bombing targets: 1. command, communication, control, and information systems of Iraqi troops; 2. radar and missile systems of Iraqi troops; 3. factories, warehouses, and experimental bases for servicing Iraqi troops, in particular, facilities of biochemical weapons and nuclear experiments; 4. airfields, ports, highways, and bridges; 5. combat troops of Iraqi units, in particular, the Republican Guards. In selecting the bombing targets, it was required that the electronic information protection system provide attributes, values, external features, and precise location, among other information about a target.

(2) Real-time monitoring of the battlefield situation: this includes the tracing and monitoring of mobile Scud missile launch pads throughout Iraq; monitoring of activities of Iraqi troops; and monitoring of Iraqi radars and communication network activities.

(3) Provide the target data as required in the execution of electronic countermeasures, and provide jamming parameters for electronic countermeasure jamming. This also indicates the targets for firepower suppression.

(4) Provide information support for combat activities of friendly troops, and ensure coordination, command, and control of the troops.

(5) Evaluation of effects of bomb destruction: this can

determine the bombing effects in a timely and precise manner, thus saving large amounts of troop strength and ammunition. Every day, the multinational forces had numerous bombing targets with high bombing intensity, therefore the evaluation of bombing effects was a very important task.

1.2. Requirements on electronic information protection

In local wars under high-tech conditions, the requirements for information protection are quite high. These requirements can be mainly generalized in the following points:

(1) Comprehensiveness. There are two aspects of comprehensiveness; one is overall coverage in space, and the other is overall protection of contents. Although there was a limited extent of the main deployment of Iraqi troops, however, since the Iraqi troops had mobile Scud missile launch pads as well as some combat capabilities of biochemical weapons, therefore it was necessary to conduct reconnaissance and monitoring throughout Iraq to provide information on all important strategic targets and military targets, including their attributes, values, sturdiness, and positions in order to determine what weapons are used for bombing the targets. There were various requirements on the information content, including radar signals, communication signals, technical parameters, terrain, images, and bugging contents.

(2) Precision. The multinational forces applied large quantities of precision guided weapons in order to precisely hit

the targets and to reduce casualties to civilians as much as possible. Therefore, it was necessary to provide precision information about targets. For example, with respect to Tomahawk cruise missiles, terrain-matching guidance and other navigation measures were applied, so it was necessary to have precision terrain data in the missile flight path.

(3) Continuity. Since there were violent combat and fast-changing battlefield situations in the Gulf War, the electronic information protection system was called upon to continuously provide various kinds of information required in combat.

(4) Timeliness: in the Gulf War, missiles and aircraft were applied in large numbers together with various fast movements of ordnance and warheads. It was required that near-real-time information be provided. During the interception of Scud missiles, there were very high requirements on timeliness. In air raids, and counter-air raids, near-real-time information protection was also required.

II. Organization of Electronic Information Protection System

To accomplish the mission of electronic information protection, the multinational forces applied large numbers of items of equipment for reconnaissance, communication, and command control to organize a vast electronic information protection system.

2.1. Reconnaissance satellites in space

(1) Photoreconnaissance satellites: they mainly included KH-11 and KH-12 photoreconnaissance satellites. The resolution of these two kinds of satellites is as fine as 0.1m. The digitized images only require 1.5h between orbital sending to ground processing via the data satellite relay communications. The photoreconnaisance satellites are very high in resolution power, but they are greatly affected by meteorological conditions. Moreover, continuous images of the same locations cannot be provided.

(2) Synthetic aperture radar reconnaissance satellites have all-weather capabilities, capable of detecting vegetation to a certain depth, as well as underground targets tens of meters deep. In addition, camouflaged and concealed targets can be distinguished. However, such satellites were still unable to provide continuous information.

(3) Electronic reconnaissance satellites: in this type, the "Large Wine Bottle," "Small House," and ADP-658 are geostationary satellites. There are also two low-orbiting satellites and dedicated information satellites. The electronic reconnaissance satellites are used for reconnaissance of radar and communication signals. The bugging frequency range of the radar was between 100MHz and 20GHz. The geostationary reconnaissance satellites could conduct continuous reconnaissance of Iraqi troops; however, since these satellites were high in orbit, there were limitations on the radar-captured signals, the communication power and

wavebeam directions. Low-orbiting electronic satellites operated in low orbits, capable of intercepting more signals. However, since their operating cycles are short and their subsatellite tracks are moving, they were not able to continuously provide information about the same location.

(4) Missile prewarning satellites were used to monitor the launch of Scud missiles. With infrared detection, the infrared telescope scanned once every 10-12s; an image was sent to ground every 30s. Since multiple early warning satellites were applied, continuous monitoring could be maintained.

(5) Maritime monitoring satellites have the code designation of *Nimbus. With infrared detection received over radio, continuous monitoring and detection of surface warships and submarines are feasible.

(6) Military meteorological satellites apply visible light, infrared rays, and microwave imaging to provide meterological information.

2.2. Airborne electronic reconnaissance equipment

The multinational forces operated more than 100 strategic and tactical reconnaissance aircraft. In addition, multiple types of reconnaissance drones were used. The main reconnaissance items of equipment applied include synthetic aperture radar, infrared detectors, and cameras, besides, E-3A/B, E-2C, and E-8A early-warning planes also had exploited important functions in information reconnaissance. An introduction is made

in the following on the performance of several types of reconnaissance craft.

(1) The SR-71 strategic reconnaissance plane has a reconnaissance height of 24km, cruising speed (at 21km) Mach3, maximum level flight speed (at 24km altitude) Mach3.2, and practical ceiling of 26.6km and range (at 24km height, Mach3.0 cruising speed without aerial refueling) was 4800km. The primary reconnaissance items of equipment included battlefield reconnaissance system, cameras, infrared and electronic detectors, AN/APG-73 synthetic aperture radars, strategic reconnaissance system, and battlefield reconnaissance system. The strategic reconnaissance system can cover 155,000km2 of area per hour.

(2) The TR-1 reconnaissance craft is a high-altitude tactical reconnaissance plane, which can continuously observe enemy targets in depth around the clock and in all kinds of weather, in addition to supporting ground and air combat. The primary reconnaissance equipment is the AN/UPD-X side-looking radar.

(3) Drones are low in cost and free of the problem of personnel casualties. These drones can conduct reconnaissance deep in enemy territory. In the Gulf War, three types of drones were operated, *Short-hair Hunting Dog of the United States, *Matte drones of France, and *Vanguard drones of Israel. The drones apply the reconnaissance equipment such as television camera, infrared imaging device, and electronic countermeasure

reconnaissance devices.

Modern drones are high in reconnaissance capability; they exploit their great functions in battlefield monitoring and target acquisition. For example, the Phoenix drone of the U.K. can accomplish battlefield monitoring, target acquisition, discriminating, and positioning, to provide precise target locations on the battlefield for artillery of intermediate and long range to approximately 50km. This system has the following features: 1. operate around the clock and in all kinds of weather; 2. continuous high-resolution images and precise locations of targets on a real-time basis; 3. cruising time is longer than 6h; 4. the drones have stealth feature; and 5. the drones have confidential communication capability between air and ground, difficult to be detected and discovered.

(4) E-8A reconnaissance and early-warning craft are equipped with side-looking radar with detection distance of 250km, capable of detecting ground and low-altitude moving targets deep within enemy territory. In addition, the target position information can be sent on a timely basis to ground commanders and air attack craft for air and ground firepower suppression.

2.3. Maritime Electronic Reconnaissance System

All the large surface ships of the United States are equipped with electronic reconnaissance devices, capable of monitoring Iraqi naval activities.

2.4. Ground electronic reconnaissance system

The ground electronic reconnaissance system is mainly the communication information station. In Turkey, Saudi Arabia, Oman, and the United Arab Emirates, the multinational forces set up scores of information communication stations to detect and listen to Iraqi communications and other electronic signals.

The various types of electronic reconnaissance systems in space, air, at sea, and on land of the multinational troops were combined into an organic entity by using the communication system capable of carrying out real-time transmission and sharing of information. From the foregoing simple presentation, we can see that the electronic reconnaissance systems of the multinational forces have several unique features: 1. comprehensiveness of the reconnaissance systems. The reconnaissance systems in space, air, on the ground, and on the sea were combined into an entity to form a multilayer omnidirectional and three-dimensional reconnaissance system; 2. the state of advancement of the reconnaissance system: radar imaging, electronic countermeasure reconnaissance, electronic bugging, visible-light photography, infrared photography, television photography, and other advanced electronic information measures were used in the reconnaissance system. Thus, target information of all aspects can be obtained to provide sufficient information sources for comprehensive processing of information. 3. Flexibility of reconnaissance system: in peacetime, the electronic reconnaissance satellites of the United States can conduct strategic reconnaissance. In

wartime, these satellites are mobile in orbit for monitoring and reconnaissance of related nations and territories.

III. Comprehensive Analysis of Electronic Reconnaissance Information

The electronic systems of multinational troops acquired large quantities of information; however, this information was mostly raw materials that needed to be comprehensively analyzed by using the information comprehensive analytical system in order to have the information that can be used by commanders at various levels. Therefore, this comprehensive information analysis is the core of the electronic information protection.

3.1. Kinds and features of electronic reconnaissance information

The various kinds of electronic reconnaissance systems acquired multiple reconnaissance information, which can be classified into the three following kinds:

(1) Imagery information includes visible-light pictures, radar pictures, infrared pictures, and television signals. The various kinds of picture information have different features.

Visible-light pictures have the highest resolution, clearly displaying terrain, ground objects, as well as various military targets such as tanks, trucks, and missile launch pads. However, these high-resolution pictures have limited field of view; the information is unable to be provided in real time. The picture quality is restricted by meteorological conditions.

By using synthetic aperture radar, radar pictures can

display terrain and images several meters deep under the soil. Moving targets such as tanks, trucks, and missile launch pads can be distinguished. In addition, positions and attributes of sand and earth fortifications can be discriminated. Radar pictures can be provided in real time, unrestricted by meteorological conditions. However, their resolution is poorer than that of visible-light pictures.

Infrared picture signals can have night views, for early warning of missiles and also can be used to search for tanks buried under sand. Infrared pictures have higher capability of discriminating camouflage.

(2) Communication information: by bugging, communication among various levels of Iraqi commanders can be acquired and tracked. From reports, all communication contents were bugged by the multinational forces as high as the supreme command organs of the Iraqi troops, to as low as communications between squad and platoon commanding officers.

(3) Electronic information: by using electronic countermeasure reconnaissance equipment, various technical parameters of Iraqi radar and communication signals can be acquired in real time for positioning of radar and communication equipment facilities, thus providing data for electronic jamming and firepower suppression. There are two portions of electronic information acquisition by the multinational forces; one is the reconnaissance before combat to basically clarify the technical data of Iraqi radar and communication signals; secondly, this is

direct reconnaissance during combat. During combat procedures, real-time monitoring and reconnaissance can be conducted on Iraqi radar and communication signals, to recheck the older signals and to discover the new signals.

3.2. Data fusion of electronic reconnaissance information

There were many types of reconnaissance equipment applied by the multinational forces with a vast amount of information, which should be automatically processed by computers. By using the data fusion techniques, by the U.S. forces, comprehension, correlation, and coordination of data acquired by multiple platforms and multiple sensors were carried out.

Data fusion has the following advantages: 1. the space coverage of the system can be expanded; 2. the time coverage range of the system can be extended; 3. the system utilization rate can be increased; 4. the believability and precision of information can be enhanced; and 5. the system investment can be reduced.

The concept of data fusion appeared in the seventies. It has been developed to a great extent since the eighties. Since data fusion has the important advantages as mentioned above, this quickly entered into many military areas. As reported, there are scores of data fusion systems in the U.S. forces; many of them were applied in the Gulf War. These were proved to have excellent effectiveness.

The data fusion can be classified into three levels as to

comprehensive processing of reconnaissance data: 1. fusion of picture element level: fusion of the raw data is carried out, such as the sorting and discrimination of radar signals of the radar countermeasures equipment; 2. fusion at the feature level: fusion is conducted on the signal features. In other words, first extraction of features is conducted prior to fusion, such as the fusion of the target appearance features acquired in the visible-light pictures and the features of visual targets obtained by electronic countermeasures reconnaissance so that the target features can be comprehensively determined. 3. Fusion at the decision-making level: fusion is conducted on the results of independent decision-making at various information channels, such as fusion on the results of the reconnaissance by various reconnaissance systems for comprehensive determination of target features and various technical parameters. In a comprehensive processing system of reconnaissance and information, the above-mentioned levels of data fusion are often coordinated.

At present, there are still few detailed reports on the data fusion systems of the U.S. forces. We cite examples of the ASAS/Ence (All-Information-Source Analysis System/Enemy Correlation Elements), to explain the functions of the data fusion system at present.

ASAS/Ence can carry out data fusion on information material from various sensors and information sources to provide precise and real time information for military commanders, and also to provide information required for controlling electronic warfare

resources by the electronic countermeasures troops.

Connected with the ASAS/Ence system are the airborne and land-based sensors and electronic warfare resources. This system can comprehensively process communication information, electronic information, picture information, and human information. The results of comprehensive processing can be applied on a three-dimensional terrain map to immediately discriminate the moving troops, barriers, troop concentration areas, approach directions of aerial targets, and intervening territories.

3.3. Capabilities of electronic information protection

In the Gulf War, the electronic information protection capabilities of the multinational forces attained a very high level. In the view of the Pentagon, the information protection capability in the Gulf War was to let the commanders immediately understand the battlefield situations for the first time in hundreds of years. Once an Iraqi battalion was deployed, the situation was immediately displayed on multinational troops monitors. Generally speaking, the electronic information protection capabilities of the multinational troops were manifested mainly in the following aspects:

(1) There was an electronic information protection system with complete structure, advanced technology, and flexible deployment. This electronic information protection system is the most advanced in the world at present.

(2) The strategic targets and military activities can be

placed under overall reconnaissance in a large area for continuous monitoring with very high discrimination capability between true and false targets. This indicates that a modern large-scale military operation is difficult to be concealed.

(3) Night-vision capabilities were greatly enhanced. Night combat has become a superiority of U.S. forces. Moreover, it reflects that in modern local wars, troops lacking night vision equipment and all-weather electronic reconnaissance equipment will find it difficult to have combat initiativeness.

(4) The electronic countermeasure reconnaissance capabilities are very high, capable of conducting real-time reconnaissance of all Iraqi radar and signal parameters and positions of most communication networks. Because of widespread applications of precision guided weapons, oftentimes this means that discovery is equivalent to destruction. Therefore, combat survivability of troops lacking counterreconnaissance capability in electronic equipment was greatly lowered.

(5) Real-time information reconnaissance and protection capability of airborne electronic reconnaissance equipment are the highest, especially the E-3A/B, E-8A, reconnaissance drones and various kinds of electronic countermeasures reconnaissance aircraft; these have key functions in real-time information protection. The E-3A/B and the E-8A have become the keys to electronic countermeasures.

IV. Defects in the Electronic Information Protection Systems

Although the U.S. forces and the multinational forces operated almost all reconnaissance systems and advanced technologies that can be applied in the electronic information protection system, however, the information protection capability is not perfect. As indicated, in actual combat procedures there are some important problems still existing in the information protection systems.

(1) There is insufficient evaluation capability of bombing results. Frequently, it is not possible to determine whether a target was completely destroyed, partially destroyed, or just slightly hit. Thus, it is not possible to correctly determine which targets should be continuously bombed. Sometimes, a target had to be repeatedly bombed, thus wasting firepower resources and ammunition. Insufficiency in evaluating the bombing effects indicates that the discriminating power of the various presently existing reconnaissance systems in the U.S. forces are still limited, especially under poor meteorological conditions, and for the dust-laden battlefield environment.

(2) There are insufficient real-time information capabilites. In violent combat, oftentimes commanders are unable to obtain real-time information, especially in poor climatic conditions. For example on January 22 and 23, it was cloudy and rainy in the Gulf area, with a lack of support by real-time information, thus restricting the air raid activities of the multinational forces. Many fighter craft and bombers returned to

base with bombs and missiles. Thus, it is apparent that real-time information is a vital integral part of combat effectiveness. Without real-time information, combat effectiveness is also lost, to a certain extent.

(3) There is insufficient capability in discriminating camouflage. Iraqi troops took advantage of the weak points of reconnaissance satellites by using camouflaging in disturbing the reconnaissance and monitoring by multinational forces satellites. In this way, the air force of the multinational troops also found it difficult to discriminate between real and false bombing targets. The camouflaged targets included dummy planes, dummy tanks, dummy missile launch pads, and dummy air bases, among others.

(4) There was insufficient friend-or-foe discrimination. In aerial combat and ground combat during the Gulf War, problems of insufficient discrimination between friend or foe appeared. Due to mistaken friend-or-foe discrimination, large numbers of casualties resulted. The problem is dramatized even further by comparing such casualties to casualties due to enemy fire. For example, in the first British armored division, there were 17 fatalities; eight military vehicles were destroyed. However, only one of the fatalities resulted from enemy fire. The other losses were from friendly fire. In the total casualties of the U.S. forces, 35 fatalities and 72 casualties were caused by friendly fire.

V. Conclusions

Since the Second World War, there were more than 160 local conflicts. For many nations, including China, the possibility of future local conflicts is the largest, as the most direct threat. As in the Gulf War, the techniques and means of electronic information protection will be extensively applied and developed in future local conflicts. Therefore, the development of future electronic countermeasures should begin with sufficient study of the techniques and measures of electronic information protection in the Gulf War. The electronic reconnaissance techniques at this level is considered as a countermeasures target in order to upgrade the electronic countermeasures troop units in China.

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